TECHNICAL BULLETIN 204 ISSN 0070-2315

THE USE OF ALFALFA CUBES AS PARTIAL REPLACEMENT FOR CONVENTIONAL ROUGHAGES AND PROTEIN SOURCES

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NICOSIA CYPRUS

SEPTEMBER 1999

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SUMMARY

In most Mediterranean countries domestically produced forage is not readily available during dry years. As a result, pelleted or cubed alfalfa of high density is imported. Two trials using 48 lactating Chios ewes (59±7.6 days in milk) and 18 Friesian cows (75±50 days in milk) were carried out to study the effect of partial replacement of long barley straw with alfalfa cubes (3.2x3.2x2.6 cm) in isonitrogenous and isofibrous diets, on milk yield and milk composition. There was no difference (P>0.1) between treatments for milk yield (Cows: control 20.9, cubes 21.2; Ewes: 1.73, cubes 1.66 kg/head/day), fat corrected milk yield, milk composition and initial and final body weight of the animals. All cows on alfalfa cubes showed mild bloat symptoms during the first 16 days of the experiment, which were restricted to four animals later on. There was no difference between diets in rumen ammonia-N concentration, but there was a trend (P<0.08) towards lower ruminal pH in ewes on cubes compared to the control group. Based on the findings of the present study it can be concluded that in dry years, imported alfalfa cubes can be used as partial replacement for scarce domestic roughages and of imported protein sources, but the introduction of cubes should be gradual (over a period of 7 to 10 days), and be proceeded by of long forage to eliminate adverse effects due to bloat.

ΠΕΡΙΛΗΨΗ

Στις περισσότερες Μεσογειακές χώρες, σε περιόδους ξηρασίας, παρατηρείται σοβαρή έλλειψη χονδροειδών τροφών με αποτέλεσμα η κυτταρίνη να αποτελεί το πιο δαπανηρό συστατικό του σιτηρεσίου. Χονδροειδείς τροφές εισάγονται από το εξωτερικό σε μορφή κύβων (κύβοι 5 ή 9 mm) ή σύμπηκτων (3.2 x 3.2 x 6.0 cm) που έχουν μεγαλύτερη (330 kg/m^3) πυκνότητα και χαμηλότερα από τους σανούς κόστα μεταφοράς. Στην εργασία αυτή χρησιμοποιήθηκαν 18 γαλακτοφόρες αγελάδες της Φρισλανδικής φυλής (Πείραμα 1) και 48 Χιώτικες προβατίνες (Πείραμα 2). Τα ζώα του κάθε είδους χωρίστηκαν με βάση τη γαλακτοπαραγωγή τους σε δύο ομοιόμορφες ομάδες και κατανεμήθηκαν τυχαία στο μάρτυρα (συμπυκνωμένο μίγμα ψηλής περιεκτικότητας σε πρωτεΐνη, 19.6% στη ξηρή ουσία, συν 5 χλγ άχυρο κριθαριού) και τη δοκιμή (συμπυκνωμένο μίγμα χαμηλής περιεκτικότητας σε πρωτεΐνη, 15.6% στη ξηρή ουσία, συν σύμπηχτα μηδικής). Στη δοκιμή, έγινε αντικατάσταση 3 χλγ αχύρου με 5 χλγ σύμπηκτων. Στα ζώα και των δύο σιτηρεσίων η ενέργεια, πρωτεΐνη και κυτταρίνη ήταν ανάλογη με τις ανάγκες συντήρησης και παραγωγής. Δεν υπήρξε διαφορά μεταξύ των δύο σιτηρεσίων, στην ολική γαλακτοπαραγωγή, λίπος, πρωτεΐνη, λακτόζη και ολικά στερεά του γάλακτος των ζώων στα δύο σιτηρέσια. Παρατηρήθηκε κάποια τάση χαμηλότερου pH στις προβατίνες που έπαιρναν σύμπηκτα μηδικής. Η διασπαστικότητα της πρωτεΐνης των σύμπηκτων ήταν 64% και ίση με δημοσιευμένες τιμές για σόγια (65%) γεγονός που εξηγεί και την ίση συγκέντρωση αμμωνίας στη μεγάλη κοιλία των προβατίνων στα δύο σιτηρέσια. Ολες οι αγελάδες που πήραν σύμπηχτα παρουσίασαν συμπτώματα τυμπανισμού τις πρώτες 16 ημέρες, ενώ μετέπειτα ο τυμπανισμός περιορίστηκε μόνο σε 4 αγελάδες. Με βάση τα πιο πάνω αποτελέσματα συμπεραίνεται πως τα σύμπηκτα μπορούν να χρησιμοποιηθούν σαν μερικό υποκατάστατο του αχύρου κριθής και σόγιας. Λαμβάνοντας όμως υπόψη τις περιπτώσεις τυμπανισμού που παρουσιάστηκαν είναι καλό τα σύμπηκτα να δίδονται σταδιακά και να ακολουθούν τη χορήγηση αχύρου ή σανού δημητριακών. Με βάση τη μέση τιμή των εισαγομένων σύμπηκτων (£100/τ) και τη παραγωγικότητα των ζώων φαίνονται πως η χρήση των σύμπηκτων είναι οικονομικά βιώσιμη όταν το άχυρο τιμάται στις £60/τ (συνθήκες ξηρών χρόνων) και η τιμή της σόγιας είναι περίπου £170/τ.

INTRODUCTION

Provision of adequate fibre is important to balance rations for ruminants. To maintain healthy ruminal function and to avoid milk fat depression, the NRC (1989) recommends a minimum of 25 to 28% fibre, measured as Neutra Detergent Fibre (NDF), with 75% of the total dietary NDF being supplied by forages. For diets that contain nonforage fibre source and minimal forage, dietary concentration of forage NDF, and particularly the particle size of the remaining dietary forage, are crucial for stimulating rumination (Grant, 1997), because most nonforage sources do not stimulate chewing as effectively as long forage. Mertens (1997) reported that chopping forages through 40 mm mesh-screens reduces chewing activity to 80% of the unchopped original material, whereas grinding of forage may reduce chewing activity to 20 to 60% of that of long forage.

During dry years in most Mediterranean countries, domestically produced forage is not readily available. Much of the forage is imported and, consequently, fibre is the most expensive component of dairy cow diets. Imported forage is pelleted or cubed to increase density and reduce shipping costs. However, the cubing and pelleting process reduces forage particle size, which reduces the time that animals spend chewing (Mertens, 1997), increases ruminal acidity (Klusmeyer *et al.*, 1990), which is associated with animals going off feed (Eriksson *et al.*, 1968), depresses fibre digestion (Whiting *et al.*, 1976), increases rate of particulate passage from the reticulo rumen (Rode and Satter, 1988), and may result in milk fat depression (Klusmeyer *et al.*, 1990). The objective of the present work was to study the effect of partial replacement of long barley straw by imported alfalfa cubes on milk yield, milk composition, ruminal pH and ammonia-N in isonitrogenous and isofibrous diets fed to lactating Friesian cows and Chios ewes.

MATERIALS AND METHODS

Two trials using lactating Chios ewes and Friesian cows were carried out to study the effect of partial replacement of long barley straw with alfalfa cubes in isonitrogenous and isofibrous diets, on their milk yield and composition. Alfalfa cubes measured 3.2x3.2x6 cm and were made from 5 cm-long dehydrated alfalfa slices. Samples of feeds offered were collected routinely, composited, and analyzed in triplicate for DM, OM, CP, CFi, ADF, NDF and ADL (Harris, 1970). *In vitro* digestibility of organic matter in the dry matter (D) of the roughages was determined following the procedure of Tilley and Terry (1963) as modified by O'Shea and Wilson (1965). In both trials, animals had free access to water.

Rumen degradability of DM, OM and CP of alfalfa cubes was measured using three Chios ewes (average weight 65 kg) fitted with permanent rumen cannulae. Fistulated animals were kept in individual pens with concrete floors bedded with wood shavings; they were fed (g/animal/day) on 500 concentrate, 250 barley hay and 250 lucerne hay. Cubes were incubated for 2, 5, 8, 24 and 48 h in nylon bags (three bags/incubation interval) in the rumen of the animals as outlined by Hadjipanayiotou *et al.* (1988). Samples were analyzed for DM, OM and CP before and after incubation. The mean of the three bags per incubation interval was used for calculations (Orskov and McDonald, 1979). Processing and handling of the samples before and after incubation was as outlined by Hadjipanayiotou *et al.* (1988).

Cows. Eighteen Friesian cows (75 ± 50 days in milk) were used. They were stratified based on individual milk yield, and randomly allocated to either the control (C) or the alfalfa cubes (A) group. Animals on the C diet were offered 5 kg of long barley straw along with a concentrate mixture high (Hc) in CP content (Table 1); animals in group A were offered 2 kg straw and 5 kg alfalfa cubes along with a concentrate mixture of low (Lc) CP content (Table 1). The two groups were housed in two adjacent open-yard pens with adequate shaded area. Roughages were fed in groups, and concentrates individually in five equal meals daily via a computerized feeding system at regular intervals throughout the day; any residues were offered in a 6th meal. The concentrate feed allowance intended to cover the remaining, in addition to nutrients supplied by the roughage, maintenance, growth (first and second lactation cows), and milk production

Table 1. Composition (kg/t) of concentrate mixtures fed to lactating Friesian cows and Chios ewes on two treatment diets

	Cows		Ewes	
Concentrate	High	Low	High	Low
Rolled barley	738	728	758	855
Soybean meal	190	100	170	73
Wheat bran	50	50	50	50
Dicalcium phosphate	2.5	2.5	3.0	3.0
Limestone	14	14	13	13
Salt	3.5	3.5	4	4
Vitamin trace element mixture+	2	2	2	2

+The vitamin-trace element mixture supplied 6000 IU vitamin A, 1000 I.U. vitamin D_3, 8.5 I.U. vitamin E, 23 mg Mn, 1.75 mg I, 45 mg Zn, 30 mg Fe, 2 mg Co and 60 mg Mg per kg concentrate mixture (as fed basis). The premix used for cows supplied also and 8 mg Cu.

requirements (NRC, 1989) were adjusted once every fortnight based on body weight (BW) at the beginning of the trial and on fat-corrected milk yield of the previous fortnight. Body weight of the cows was recorded on two consecutive days at the beginning and at the end of the 63-day trial. Individual milk yields were recorded daily. Milk samples were analyzed for fat and protein (MAFF, 1973) once every fortnight. Data were analyzed using a general linear model procedure (SAS, 1989) that accounted for treatment (Control or Cubes), lactation number (1, 2 or 3), treatment by lactation number interaction and days in milk as covariate.

Ewes. Forty eight Chios ewes of 59 ± 7.6 day in milk were used. They were paired based on individual milk yield, and randomly allocated to either the control or the alfalfa cubes group. The two groups were housed in two adjacent pens. Ewes on the control group were offered 0.76 kg of long barley straw plus a concentrate mixture of high (He) CP content (Table 1) to meet their requirements for maintenance (0.401 MJ ME/kg $W^{0.73}$) and milk yield (Economides, 1986). Dietary ME MJ per kg of milk was estimated from the equation Y=((1.94 + 0.43X)/0.62), where X is fat percentage and 0.62 the efficiency of utilization of dietary ME for milk yield. Ewes were machine milked at 07.00 and 14.30 h. Individual milk yields were recorded twice a week on two consecutive days during the 50-day experimental period. Milk samples were analyzed for fat, lactose, total solids and CP (MAFF, 1973) four times through the trial. Ewes were weighed on two consecutive days at the beginning and at the end of the trial. Ewe performance data were analyzed using a general linear model procedure (SAS, 1989) that accounted for treatment (control or alfalfa cubes), lactation number (2, 3, 4, 5, 6, 7, 9), treatment by lactation number interaction and initial milk yield as covariate.

RESULTS

The chemical composition of concentrates and roughages is in Table 2. The effective DM, OM and CP degradability of alfalfa cubes at 5% outflow rate were 50, 46 and 64%, respectively. There was no difference either in the mean group intake of CFi, NDF and ADF intake or in the concentration of the two total diets. Data from one cow and one ewe on the control group were excluded from the analysis because of mastitis, which was not associated with dietary effects. All cows on alfalfa cubes showed mild bloat symptoms during the first 16 days of the experiment. Later on, bloat signs were restricted to 4 cows, but one of them showed a serious bloat problem and was punched with trocar.

Data on the performance of lactating Chios ewes and Friesian cows are in Table 3. There was no difference (P>0.1) between treatments for milk yield, fat corrected milk

Table 2. Chemical composition (g/kg DM) of concentrate mixtures and roughages used in the two trials

	DM	OM	CP	CFi	ADF	NDF	ADL	D
Cow trial								
Concentrate (High)	887	960	196	54	72	196	10	868
Concentrate (Low)	886	960	156	40	72	202	11	843
Barley straw	900	926	39	394	504	802	47	421
Alfalfa cubes	890	886	170	274	347	428	72	563
Ewe trial								
Concentrate (High)	880	950	179	59	75	231	20	ND
Concentrate (Low)	875	947	141	49	66	233	26	ND
Barley straw	897	946	48	390	451	759	50	405
Alfalfa cubes	879	882	179	270	357	452	82	555

ND= not determined.

Table 3. The effect of feeding alfalfa cubes on the lactation performance of Friesian cows and Chios ewes

	Cows			Ewes		
Treatment	Control	Cubes	SD	Control	Cubes	SD
No. of animals	8	9		23	24	...
Milk yield (kg/day)	20.87	21.20	3.46	1.73	1.66	0.40
FCM (4%) yield (kg/day)	21.02	20.14	2.64	...	...	...
Milk composition (g/kg)						
Fat	40.4	37.3	5.89	64.0	67.0	7.7
Crude protein	32.3	30.9	1.47	57.0	57.0	3.2
Lactose	...	...	...	51.0	51.0	2.1
Total solids	...	...	...	181	181	9.1
Rumen NH_3-N (mg/100ml)	...	...	...	24	22	6.3
Rumen pH	...	...	...	6.7	6.5	0.28
Feed intake (kg as fed basis/head/day)						
Concentrate	13.81	11.44	1.36	1.98	1.80	...
Alfalfa cubes	...	5.0	...	...	0.61	...
Straw	5.0	2.0	...	0.68	0.39	...
CFi intake (g/h/day)	2417(144)	2648(161)	...	340(145)	361(147)	...
ADF intake (g/h/day)	3110(186)	3594(219)	...	405(173)	456(185)	...
NDF intake (g/h/day)	5978(357)	6139(374)	...	866(370)	882(359)	...
Initial BWT (kg)	556	559	47.6	66.5	66.9	5.65
Final BWT (kg)	555	544	38.7	69.0	68.8	6.76
BWT change (g/day)	-19	-24	269	51	40	9.00

Values in parenthesis are concentrations (g/kg DM); BWT= body weight.

yield, milk composition and initial and final weight of the animals. The lactation curves of cows and ewes on the two treatment groups (Fig. 1 and 2) show that response to treatment was similar throughout the experiments, and the signs of bloat most likely did not seriously affect milk yield. There was no difference between diets in rumen ammonia-N concentration, but there was a trend towards lower ruminal pH in ewes on cubes compared to the control group.

DISCUSSION

Although roughage is accepted generally as reducing the degree of bloat, alfalfa hay is

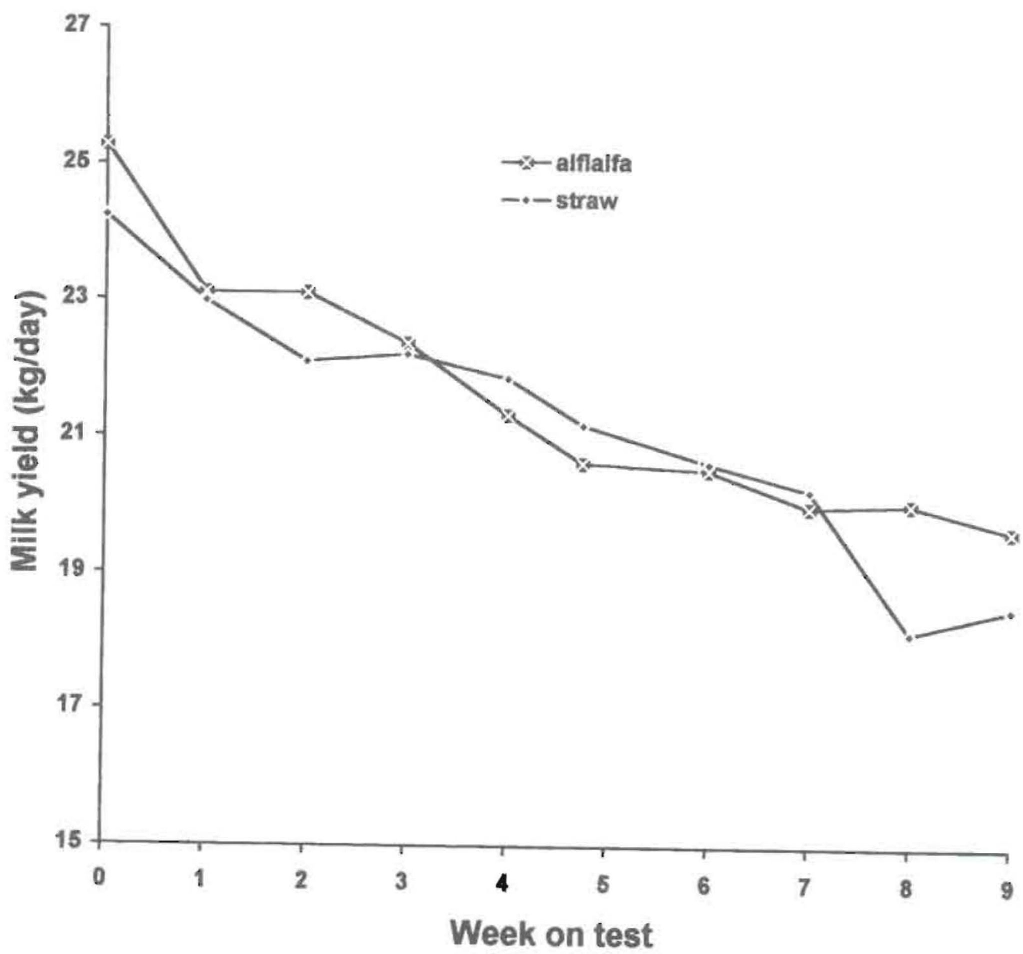

Figure 1. Daily milk yield of cows fed on isonitrogenous diets with either alfalfa cubes or barley straw.

considered by feedlot operators to be a bloat-provocative roughage (Clarke and Reid, 1974). Frequent incidence of bloat symptoms was noted in cows on the alfalfa cube treatment in agreement with Howarth *et al.* (1986) who indeed, reported that the superior nutritive value of lucerne is reduced by frequent and often severe bloat. The present findings showed that alfalfa cubes can be used as partial replacement for long barley straw. The incidence of bloat, however, should not be overlooked, and cows should be gradually adjusted to cubes. Inter-species differences in bloat occurrence observed in the present study, agree with the conclusion of Clarke and Reid (1972) that although bloat may occur also in sheep, it is predominantly a disorder of cattle.

Several experiments reveal that the protein in alfalfa is utilized inefficiently by lactating cows. Cows produced less protein and milk with depressed protein content when fed alfalfa silage or hay than when fed isonitrogenous diets based on corn silage and soybean meal (Broderick, 1985). The lower protein value of alfalfa has been ascribed to susceptibility to degradation in the rumen. In the present study, nitrogen in alfalfa cubes was utilized as efficiently as that of the control diet (straw plus soybean meal); the latter can be ascribed to an increase in the net escape of dietary protein due to heat of alfalfa prior to cubing. The effective CP degradability values of cubes (64% at 5% outflow rate) used in the present studies were lower than those previously reported (NRC, 1989) for alfalfa hay (72%) and silage (77%) and close to values for soybean meal (65%) reported by the same agency; the latter is in accordance with the same levels of rumen ammonia-N and the absence of differences in milk yield and milk protein content in the two

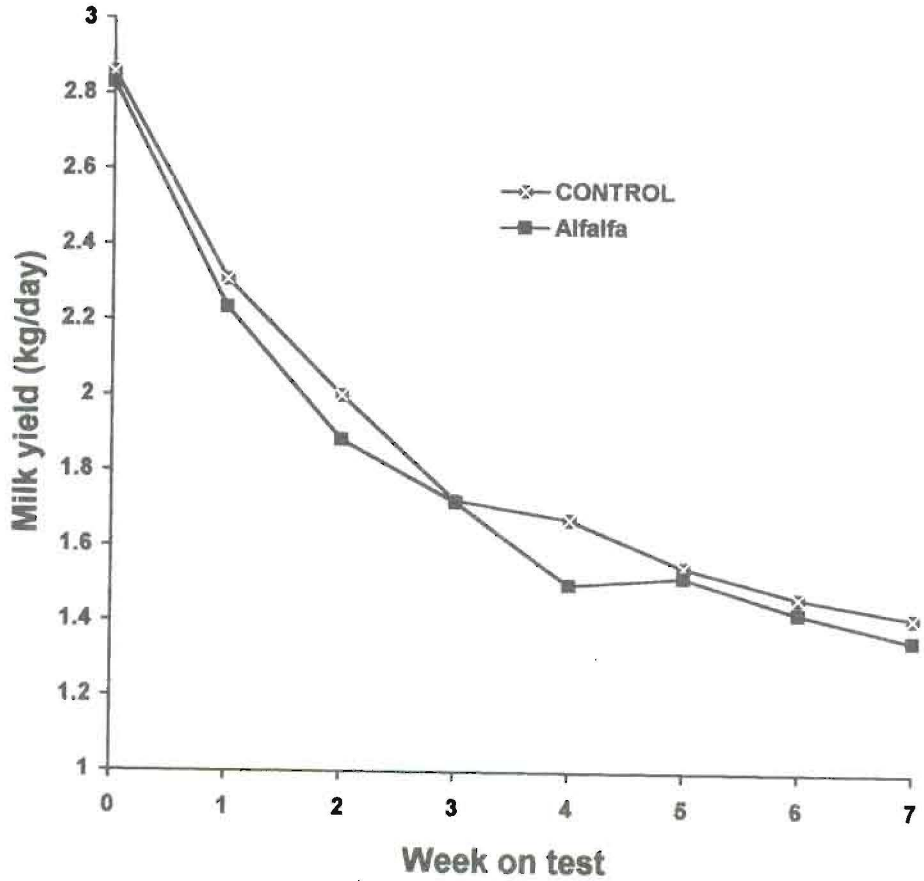

Figure 2. Daily milk yield of ewes fed on isonitrogenous diets with either alfalfa cubes or barley straw.

diets.

Beauchemin and Rode (1997) stated that the optimal NDF concentration depends on the milk yield potential of cows; 4% fat corrected milk yield (FCM) was maximal at 36% NDF for cows in late lactation that yielded around 20 kg/day, but 32% NDF optimized FCM yield for cows that yielded 30 kg/day in early lactation. The concentration of NDF (around 36%) in the present studies, therefore, was optimal for both treatments, and the animals could attain their maximum potential. Our findings agree with those of Poore *et al.* (1991) where dry matter intake and actual and fat corrected milk yield were not influenced by forage NDF source. Circa 60 and 68% of the dietary NDF was supplied by forage in the control and the cube diet, respectively, which are lower than those (75%) recommended by NRC (1989).

Generally, total chewing time decreases as dietary forage NDF or particle size decreases. However, in some instances, rumination per unit of forage NDF intake increased when the dietary NDF concentration and forage particle size were reduced. This has been ascribed to an adaptive mechanism, whereby cows ruminate more effectively (more chews per kg of forage NDF intake) under conditions leading to less chewing activity (Grant, 1997). The latter might explain the non significant difference in rumen pH between the two diets in the present work.

The present studies, in line with others, have demonstrated that it is physiologically feasible to feed alfalfa cubes as partial replacement for long forages and protein supplements. With a mean price for alfalfa cubes of £100/t, and prices for different feed ingredients and milk presented in Table 4,

Table 4. Economic analysis of the data for lactating Friesian cows offered dehydrated alfalfa cubes (A) or a conventional (C) diet

Price of soyabean meal (£/t)	130				170				180			
Price of barley grain (£/t)	45		80		45		80		45		80	
Price of straw (£/t)	30	60	30	60	30	60	30	60	30	60	30	60
Feed costs (£/cow/day)												
Control	0.88	1.03	1.17	1.32	1.13	1.28	1.49	1.64	1.16	1.31	1.52	1.67
Cubes	1.20	1.26	1.53	1.59	1.25	1.31	1.58	1.64	1.26	1.32	1.59	1.65
Returns above feed costs (£/cow/day)												
Control	2.77	2.62	2.48	2.33	2.52	2.37	2.16	2.01	2.49	2.34	2.14	1.99
Cubes	2.51	2.45	2.18	2.12	2.46	2.40	2.13	2.07	2.45	2.39	2.12	2.06

Price (£/t) of cow milk and of other individual feed ingredients: cow milk 175; wheat bran 60; urea 124; dicalcium phosphate 207; limestone 22; salt 80; vitamin trace element mixture 802.

the use of alfalfa cubes can be economically justified only if the price of straw is £60/t and that of soybean meal (45% CP as fed basis) around £170/t.

ACKNOWLEDGEMENTS

The authors are grateful to G. Kyprianou, G. Hadjigavriel, L. Hadjiparaskevas, A. Photiou, M. Theodoridou, M. Karavia and the staff of the Central Chemistry Laboratory for skilled technical assistance.

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